No. 3 OF THE SERIES—AIR FILTRATION IN THEORY AND PRACTICE

DESIGNING AN AIR FILTER INSTALLATION

Technical Data and General Information Covering the Selection, Application and Installation of all Standard Types of American Air Filters.

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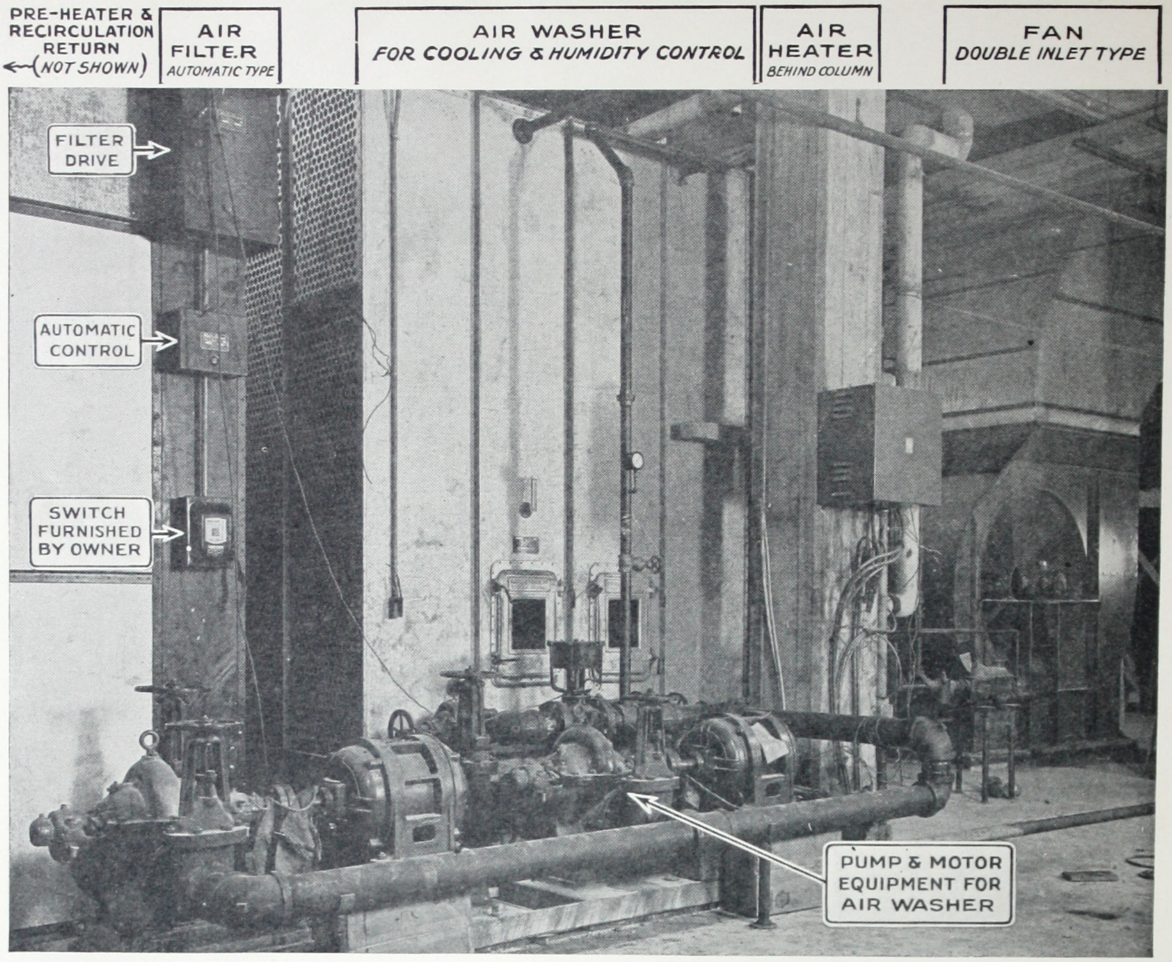
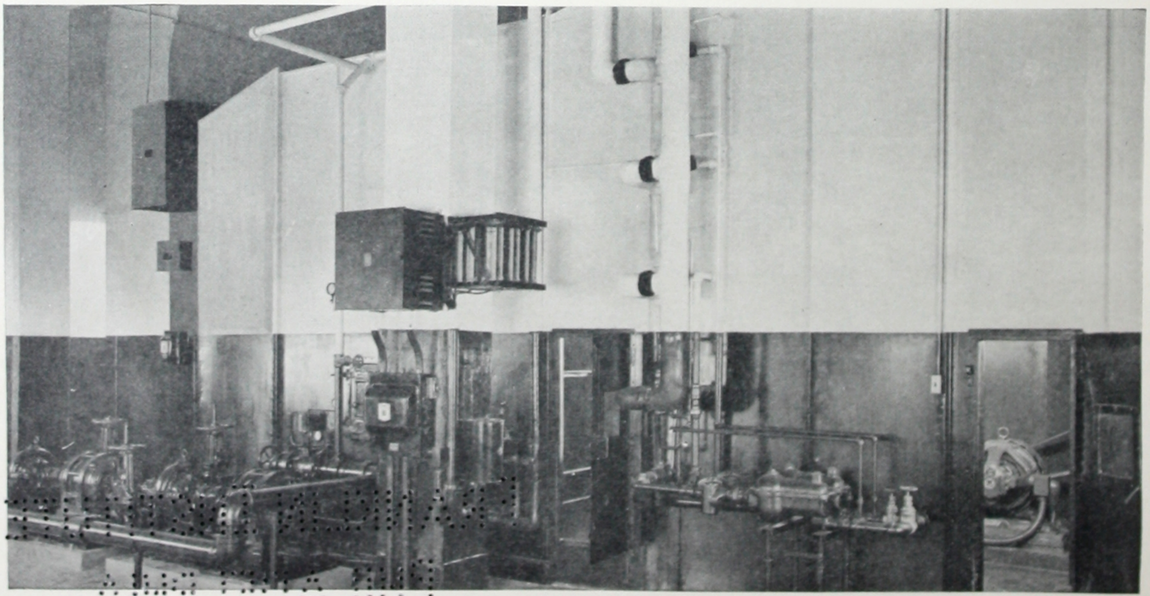
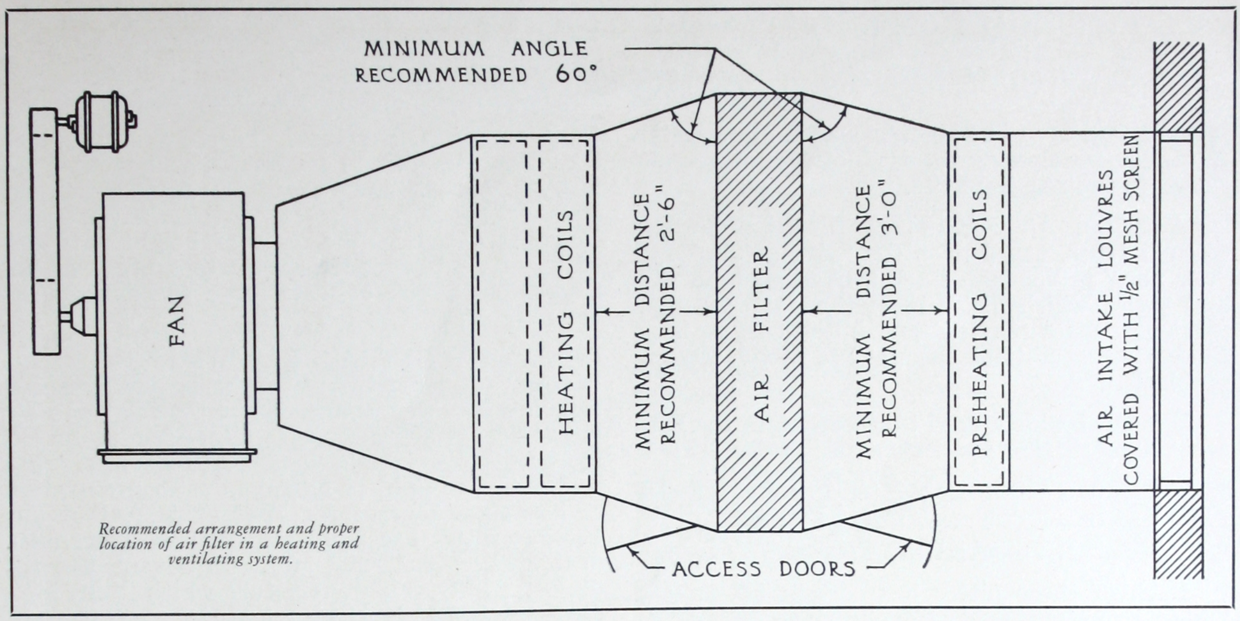


A well designed Air Conditioning System under construction showing component parts in position ready for sheet metal connections. (Below—*the finished installation.*) *The air filter is properly located ahead of the washer so that all dirt will be collected at one point to simplify maintenance, prevent contamination of the spray water, and eliminate clogging of strainers and nozzles.*





Recommended arrangement and proper location of air filter in a heating and ventilating system.

DESIGNING AN AIR FILTER INSTALLATION

THE modern air filter, while a complete unit in itself, can function as an air cleaner only when operated in conjunction with other equipment. It is usually part of an air supply system in which are included fans, heaters and other devices for conditioning the air.

The performance of the filter, therefore, not only depends upon its inherent qualifications for the specific requirements, but may be materially affected by its location in relation to other component parts, which make up the system.

Maximum efficiency and satisfactory operation can be obtained only by careful consideration of certain important factors in designing an air filter installation.

Because each air filter installation is more or less individual, depending upon the volume of air to be cleaned, the space available for the equipment, the operating conditions and the results to be accomplished, the relative importance of these factors will vary in almost every case. In each instance, therefore, they must be considered on the basis of their relative importance to insure satisfactory performance and the desired results.

American Air Filters embody the knowledge gained from more than ten years of research and practical experience in the field of air filtration.

They have been simplified in design and improved in performance to such a degree that they will operate even under the most adverse conditions, but regardless of the quality built into a filter, the results obtained will depend upon how well suited it is to the particular service and the manner in which it is applied and installed.

To assist engineers in designing installations of various types of American Air Filters, we offer the following recommendations, illustrated with typical examples selected from thousands of actual installations. If carried out as suggested the air filters will prove an excellent investment to the user and reflect favorably upon the designer of the system.

THE important factors to be considered by the engineer in designing an air filter installation are:

1. Selection:
- A. PROPER TYPE, FOR—
  - *a. Air volume*
  - *b. Dust concentration*
  - *c. Operating conditions*
  - *d. Available space*
  - *e. Maintenance facilities*
  - *f. Initial and operating costs*
- B. PROPER SIZE, FOR—
  - *a. Fan capacity*
  - *b. Allowable static pressure*
  - *c. Operating resistance*

2. Application:
- A. LOCATION IN SYSTEM
  - *a. In relation to fan*
  - *b. In relation to heaters*
  - *c. In relation to recirculation*
- B. UNIFORM AIR FLOW
- C. ACCESSIBILITY
- D. LOCATION OF INTAKE

3. Installation:
- A. PROPER DUCT DESIGN
- B. AIR-TIGHT DUCT CONNECTIONS
- C. LOCATION OF DRAFT GUAGES
- D. WEATHER PROTECTION

I. SELECTION OF FILTER TYPE AND SIZE

(A.) PROPER TYPE

THE first step in planning an air filter installation is selecting the type of filter best suited to the requirements.

American Air Filters are furnished in two distinct types, based upon the "viscous film" and "dry mat" principles. Each type is made in several styles which differ in method of operation, servicing, space required and initial cost to meet the various conditions encountered in air cleaning problems.

The most widely used types of filters for both general ventilation and industrial service are:

1. AMERICAN MULTI-PANEL AUTOMATIC FILTER.
2. AMERICAN DRY TYPE AIRMAT FILTER.
3. AMERICAN VISCOUS UNIT FILTER.

Each of these filters has certain advantages within its natural field of application. The determining factors for the selection of the filter are manifold, and while some of the points may be strictly defined, others are subject to more liberal interpretation.

AIR VOLUME. Where large volumes of air are to be cleaned, the automatic filter is preferable because in large capacities self-cleaning filters cost no more than manually-serviced types and require considerable less maintenance. Airmat and unit filters are better adapted to small or medium sized installations, although both types may be used to handle large volumes of air in cases where low headroom or other factors make it impractical to install automatic filters.

While the air velocities through various types of filters range from 50 to 500 ft. per minute, the "overall velocity", measured over the face of the entire filter including structural members, reservoirs and other component parts, is very close to 300 F. P. M. for all types.

For a given air volume, therefore, all standard American Air Filters mentioned will require approximately the same frontal area and, theoretically at least, will fit equally well in a given space. In actual practice, the ratio of height to width of the available space is important and may influence the choice of filter for a specific application.

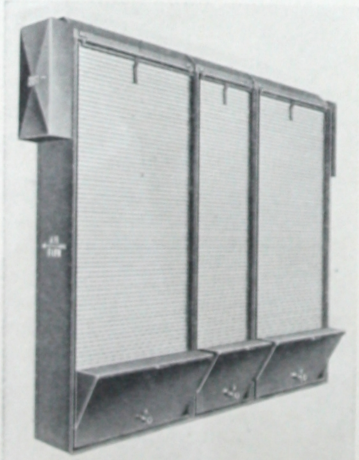
DUST CONCENTRATION. Where the air is heavily ladened with atmospheric dust, viscous type filters are recommended; units for small air requirements and automatic filters for intermediate and large installations. Airmat filters are best suited to light or average dust concentration of less than 1 grain per 1000 cubic feet of air. Viscous filters are more practical with granular dust, while the Airmat offers an advantage with dust of a linty or fibrous nature which it can handle successfully in large quantities.

MAINTENANCE FACILITIES. All filters require some attention, but self-cleaning filters need proportionately less maintenance than the manually-serviced types. Airmat or Unit filters, to operate satisfactorily, must be properly serviced at regular intervals, and dependable labor must be available for this maintenance.

In addition to labor required for changing, cleaning and recharging Unit filters, space must be provided for the necessary tanks in which the filter cells are washed and recharged, and provision made for hot water, or steam where steam cleaning tanks are used, and sewer drain connections.

The maintenance of Airmat filters is much easier and simpler than that of viscous Units and no auxiliary maintenance equipment is needed other than a supply of Airmat sheets which may be stored in any convenient place near the filter.

When access to the filter is difficult due to

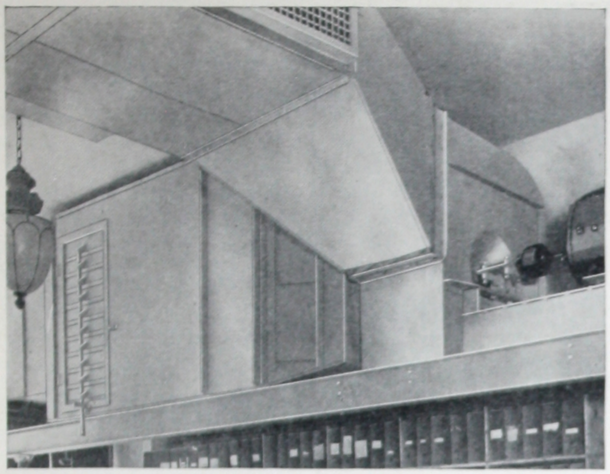


Multi-Panel Automatic Air Filter.

American Viscous Unit Filter.

American Air Filters are of two basic types—viscous and dry. Viscous filters are furnished in two standard designs—automatic self-cleaning and manually serviced units. Airmat Dry Filters, are available in Pocket or Cabinet types.

Airmat Pocket-Type Dry Filter.



An overhead installation supplying filtered air ventilation for an office without sacrificing valuable floor space. Note recirculating louvres at left.

space limitations or where regular and systematic maintenance is not to be expected, an automatic filter should be employed regardless of the size of installation.

AVAILABLE SPACE. Where headroom is very low or for small overhead installations the viscous unit or Airmat filters are at an advantage, since with automatic filters a certain amount of height is taken up by reservoirs and hoods. Where headroom is ample, automatic filters are greatly to be preferred, since the maintaining of manually serviced filters arranged more than seven feet high requires ladders or auxiliary platforms, and even with such provisions maintenance will prove to be an arduous and easily neglected task.

Where space is limited so that filter cannot be installed in one straight bank, filters constructed of small units such as the viscous unit and Airmat type are somewhat more flexible than the automatic filter, and can be arranged to obtain the best possible air distribution. Freak arrangements should be carefully avoided and in every case the filter should be arranged to provide as nearly uniform air distribution as possible over the entire face area of the filter. The published performance data for any type of filter is always based on "straight-through", unrestricted air flow.

The depth of the filter in the direction of air flow is another factor which may dictate the use of one certain type of filter for a given condition. The depth varies with the type, the unit filter installation being only 4 inches deep, the automatic filter 18 in. and Airmat filter, having the greatest depth, 2 ft. 3 in. Every filter installation also requires additional space for inspection and servicing. The unit filter may be installed in the most restricted space, while more room is required for the automatic and still more for the dry type filter.

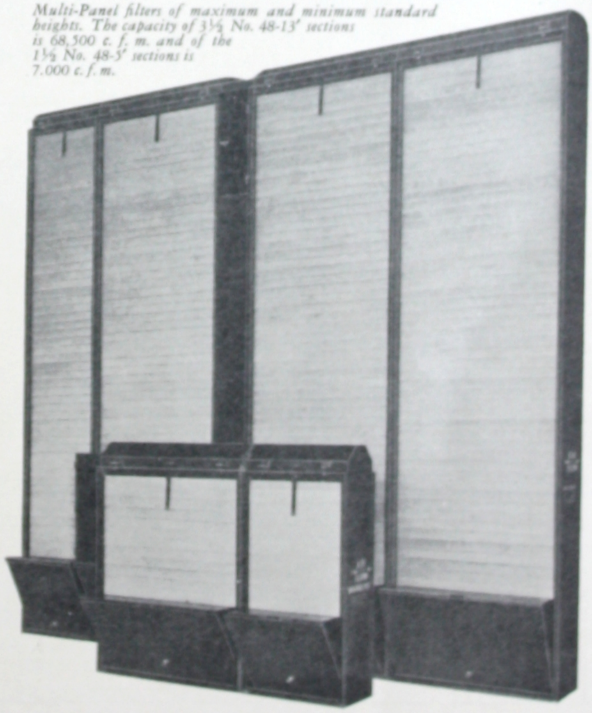
OPERATING CONDITIONS. Filters of all three types are applicable to and will operate successfully in the average air supply system. Where the operating time approaches 24 hours a day, and especially for continuous duty as required by many industrial applications, the automatic filter is preferable. Automatic filters are also desirable whenever it is important to maintain absolutely constant operating resistance in the face of a heavy dust load.

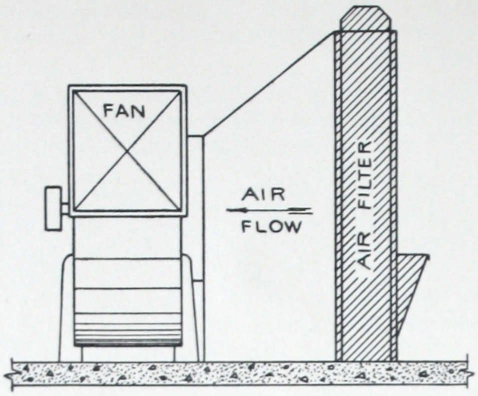
Experience has proven that automatic filters are economical under practically all operating conditions, and for all capacities greater than 3000 C. F. M. Large installations of the viscous unit type are seldom desirable due to the maintenance requirements. Airmat installations of large capacity are practical only where provision can be made to recondition the filter sheets by means of automatic vibrators or vacuum cleaning, thus reducing the frequency with which they must be renewed. Even under these conditions, the Airmat will require more maintenance than automatic filters of the same capacity.

BALANCING FIRST COST AND OPERATING EXPENSE. In selecting an air filter for a given installation, the initial cost of the filter should be balanced against expense and convenience of maintenance to insure an installation that will be economical in operation and satisfactory in performance.

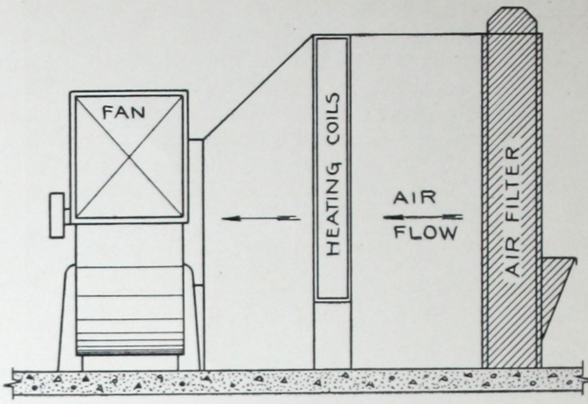
The unit type viscous filter is low in first cost, but its maintenance is higher than that of the other types. The Airmat filter is next in price and also requires manual service, but the amount of attention needed is reduced and maintenance is greatly simplified. The automatic filter, while higher in first cost, is so designed as to require practically no maintenance The cost of electric current for the fractional horsepower motor is negligible, and the only expense in operating an automatic filter consists of replacing the small quantities of filter liquid which have been removed with the sludge.

Multi-Panel filters of maximum and minimum standard heights. The capacity of 3½ No. 48-13′ sections is 68,500 c. f. m. and of the 1½ No. 48-5′ sections is 7.000 c. f. m.

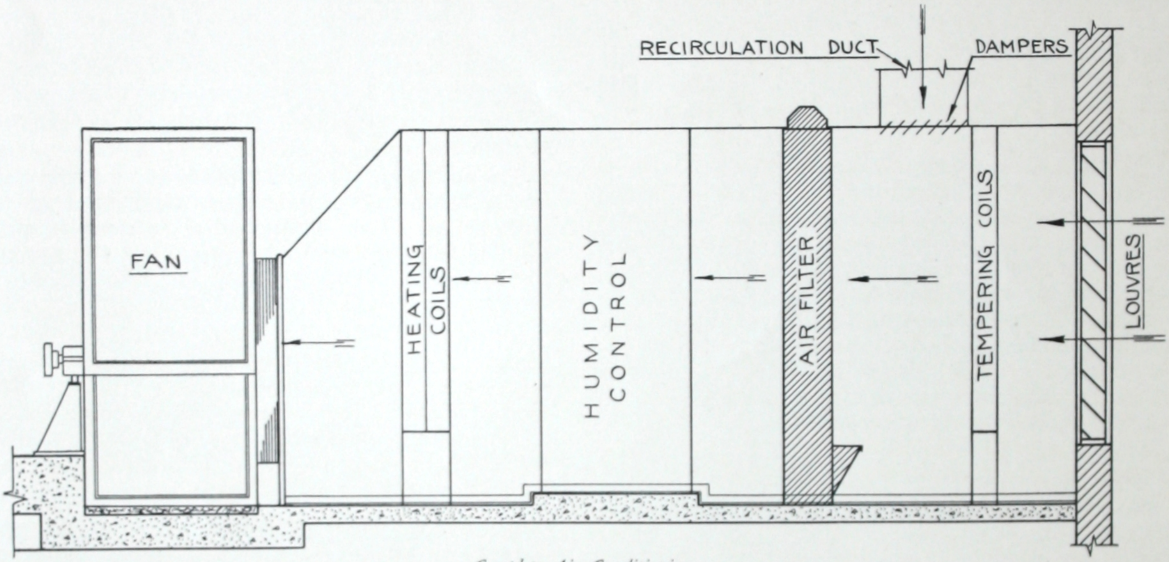




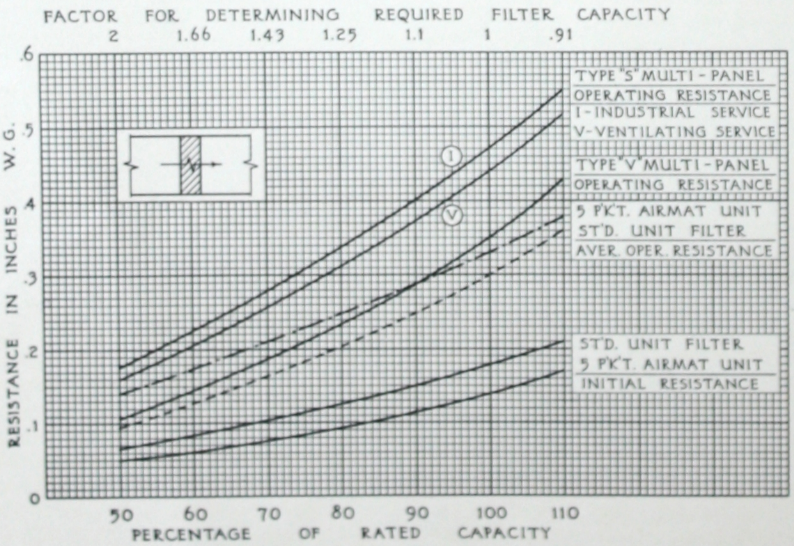
Simple Ventilating



Heating and Ventilating



Complete Air Conditioning



CAPACITY-RESISTANCE CURVES

These curves, plotted to show the average operating resistance of standard types of American Air Filters and initial resistance of Unit and Airmat filters at various percentages of rated capacity, are based on straight-through, uniform air flow and average dust conditions.

The factors at the top of the chart are for determining the filter capacity required for a given operating resistance.

Example: What capacity Type "S" Multi-Panel would be required in industrial service to handle 10,000 C.F.M. at an operating resistance not to exceed .28" w.g.?

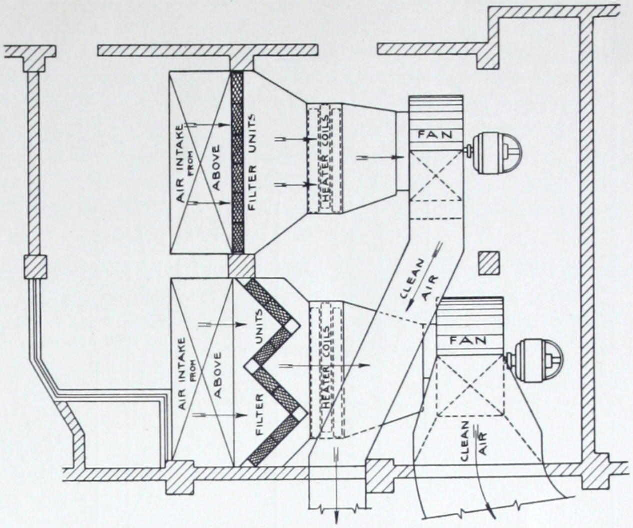
10,000 C.F.M. x 1.43=14,300 C.F.M.

The ratio of first cost for the three types of filters is variable and depends greatly upon the size of the installation. For small air volumes, the span between the cost of an automatic filter and the Airmat and unit filters is quite large, but the price difference decreases considerably as the the size of the installation increases. On medium sized installations, the Airmat filter is somewhat higher, but its easier maintenance deserves very careful consideration.

RATIO OF FIRST COST PER 1,000 C. F. M.

Capacity CFM	3,000	5,000	10,000	20,000	50,000	75,000	100,000
UNITS	10	8	7.4	7.3	6.0	5.8	5.6
AIRMAT	10	9.7	9.1	8.7	8.4	8.2	8.0
AUTOMATIC	35	22	12.6	11.0	7.1	6.3	6.2

The general preference for the various types of filters can best be shown by the fact that of the total number of installations made during the past three years, 65% have been Automatic, 20% Units and 15% Airmat.



Two installations of American Unit Filter in the Book Cadillac Hotel, Detroit showing straight-line and staggered arrangements.

(B.) CORRECT SIZE

FAN CAPACITY. The capacity of an air filter is usually specified to correspond with that of the fan. Better practice, however, is to use a filter with some excess capacity, particularly if there is any question about the actual volume of air to eventually be delivered. Government specifications for Federal buildings usually call for a filter of ten percent greater capacity than the fan rating. Many consulting engineers have also adopted this as standard practice. Since the performance characteristics of an air filter are based upon its being operated at rated capacity, the filter size should always be selected from the published data of the manufacturer with due consideration of the conditions under which it is to operate.

ALLOWABLE STATIC PRESSURE. In designing an air supply system the operating resistance of the filter, ordinarily a small part of the total static losses, is included when calculating the required fan size. When filters are applied to an existing system it may be necessary to increase the fan speed to provide the added static pressure for the filter. Where this is not possible, as with direct connected fans, the filter capacity should be proportionately increased to lower the operating resistance sufficiently so that it will come within the allowable excess static pressure of the fan.

Due to such factors as dust concentration, air distribution, operating conditions, arrangement of the filter, etc., which are seldom comparable in any two installations, it is practically impossible to predetermine the exact resistance at which a filter will operate. It has been necessary, therefore, to establish an average operating resistance for each type of filter, based on the experience of of a large number of installations.

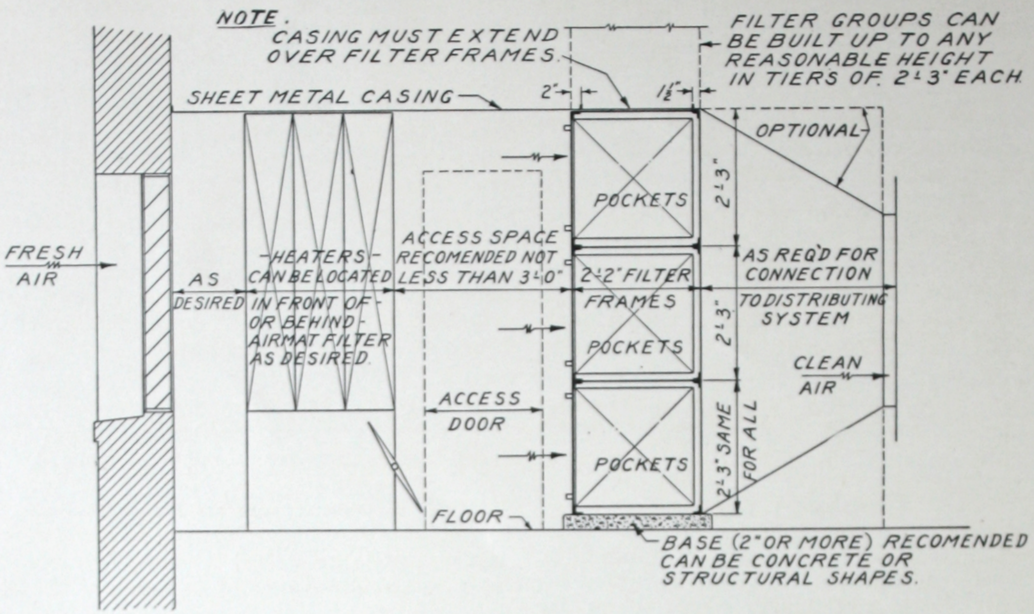
If the filter selected is of the proper capacity and correctly applied its operating resistance should closely approximate the established average. A slight variation in the operating resistance of a filter above or below the average will not appreciably affect the performance of the system. A difference of as much as .10″ in static pressure, for instance, represents only 1/40 H.P. per 1,000 C.F.M., so that a variation of a few hundredths of an inch in the resistance of the filter should be well within the operating range of the fan.

In the early days of air filtration, low resistance was considered an important factor in filter design, but with the increased knowledge of the relationship between operating resistance, cleaning efficiency and maintenance requirements, engineers now appreciate the advantage of allowing as much static pressure for the filter as necessary to obtain the desired results.

OPERATING RESISTANCE. The operating resistance of an air filter is determined principally by its basic design and cycle of operation. In an automatic filter the resistance will vary slightly with the volume of dust in the air, but when once established for a given operating condition will remain practically constant. With some types of automatic filters the cycle of operation can be adjusted to meet the operating condition, but as a rule the only satisfactory method of reducing the operating resistance is to provide increased filter capacity where necessary.

The Type "S" Multi-Panel filter is designed to operate at a resistance of from .45″ to .47″ w.g.; and the Type "V" at .35″ w.g. under average operating conditions.

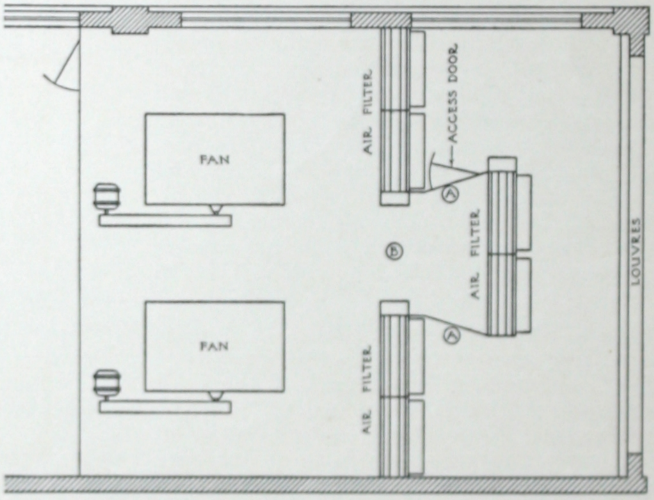
With manually maintenanced filters, such as Units or Airmat, the resistance increases gradually as the dust accumulates in the filter. When the filter is reconditioned the resistance returns to the point at which it started, which is called the initial resistance. It is possible, therefore, with manually maintenanced filters to maintain an average operating resistance at almost any point above the initial resistance by regulating the frequency of the maintenance routine, but ordinarily where a filter has to be completely

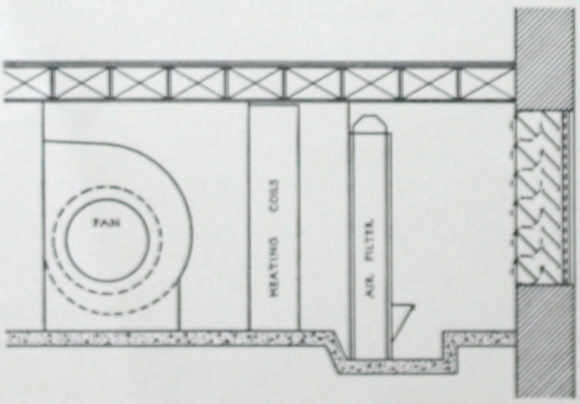


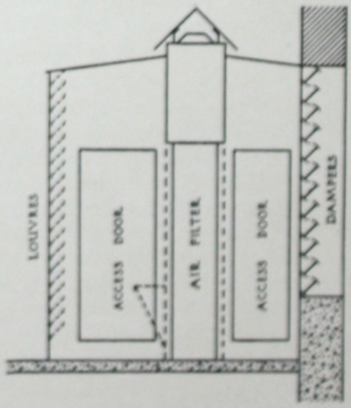
(Above) *Typical heating and ventilating system with Airmat filters. At least 3 feet of clear space must be provided for removing the Pockets to change the Airmat sheets.*

(Right) *Staggered arrangement of a Multi-Panel filter made necessary by limited space. Such an arrangement is entirely satisfactory provided the angle between the offset connections (A) and the adjacent filter sections is not less than 45°—preferably 60°—and the air velocity thru opening (B) is not more than twice the recommended velocity thru the filter.*

(Below) *An installation where low headroom made it necessary to lower basement floor to obtain correct filter capacity.* (At right) *Proper weather protection for outside installation.*







reconditioned more often than once every five or six weeks the expense of increased maintenance will amount to more than the first cost of providing additional filter capacity to meet the requirements.

Unit and Airmat filters are designed to operate at a resistance of from .30″ to .35″ w.g., under average conditions with normal maintenance.

Overloading any type of filter more than 10% of its rated capacity will seriously affect its performance characteristics. Theoretically, resistance increases with the square of the velocity, but in practice the actual rate of increase varies with different types of filters. As the velocity of the air through the filter medium increases not only is the initial resistance increased but the excess dust load resulting from the greater air volume causes a more rapid increase in operating resistance which in turn means more frequent maintenance and higher cost of operation. Also the carefully balanced action of dust separation in the filter medium is disturbed, which naturally effects the cleaning efficiency of the filter.

Similarly, reduced air volume effects the performance but the results of underload are much less serious than those of overload. It is generally accepted that 10% is the maximum allowable overload, whereas a reduction in capacity of as much as 50% is permissable.

2. APPLICATION OF AIR FILTERS

(A.) LOCATION IN SYSTEM

RECOMMENDATIONS for laying out air filter installations are substantially the same as would apply to any other type of equipment through which a uniform flow of air must be passed. Filters are particularly sensitive to improper air distribution and suffer considerably from eddy currents and dead air spaces. Especially if conditions are unfavorable and the arrangement is cramped, the greatest attention should be given to the filter application.

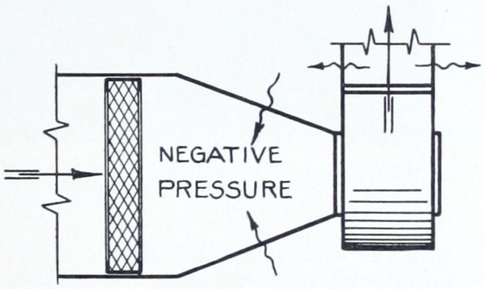
LOCATION IN RELATION TO FAN. A filter will operate equally well whether placed on suction or discharge side of the fan. It has become standard practice, however, to locate the filter at the fan inlet for three reasons—(1) simpler duct connections; (2) reduction of static pressure losses; and (3) more even air distribution over entire filter area.

Where an exceptionally high standard of dust removal must be maintained it is often advisable to place the filter on the discharge side of the fan. This arrangement offers an advantage in that the air pressure on the clean air side of the filter is outward and thus any leaks in the duct will permit the escape of clean air instead of admitting unfiltered air. Another advantage of placing the filter after the fan is the reduction of fan and air noises resulting from the muffling effect of the filtering media.

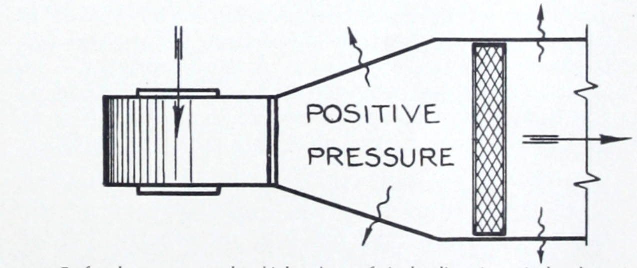
This type of installation is sometimes recommended for certain industrial applications where a liberal amount of space is available and an extreme degree of air cleanliness is required.

LOCATION IN RELATION TO HEATING COILS. In ventilating installations, heating coils are usually placed near the air inlet. The recommended velocities over the face of coils and filters are about the same and it is convenient to combine the installation of filters and heaters which makes simple and economical connections possible. It also saves on static pressure drop, as the air passes uniformly through heating coils and filter at low velocity and then goes to the fan with gradually increasing velocity.

The ideal location for the filter in such an installation is between the preheater and the main heater. A preheater is desirable with all types of filters to provide some degree of comfort for winter maintenance. With viscous filters, particularly the automatic type, preheating the air is es-



This arrangement is standard practice.

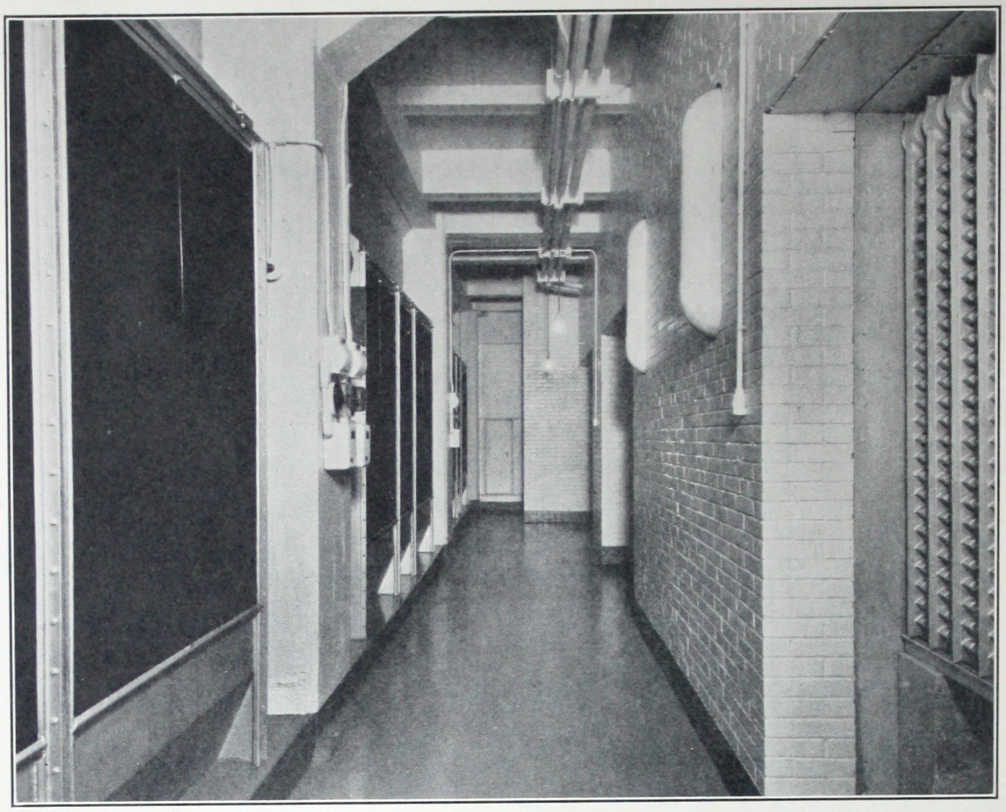


Preferred arrangement where highest degree of air cleanliness is required and space will permit. It is essential that distance between fan discharge and filter must be sufficient to insure even air distribution over entire filter area.

pecially recommended to maintain the temperature of the Adhesine within its most effective range.

If it is not practical to have a preheater then the location of the filter will depend upon the temperature of the air leaving the main heater. If the temperature of the heated air is less than 100° then the filter may be placed **after** the heater, otherwise it should go **before** the heater. Airmat filters are not affected by air temperatures and may be located either before or after the heater. An advantage of placing the filter in front of the heater is the protection it affords the heating surfaces from dust deposits.

The distance between the filter and the heating coils must be sufficient to prevent radiant heat



An ideal installation of Multi-Panel Automatic Air Filters in the Southwestern Bell Telephone Company Building, St. Louis, Mo. The walls are white enameled and the floor is painted blue grey. Note the ample space between back of filters and the heater.

from evaporating the viscous coating on the filter screen, especially after the fan has been shut down or as in some cases where the steam is turned into the heaters some time before the fan is started in the morning. A minimum space of 2 feet should be provided if the filter is ahead of the heater which may serve at the same time as access chamber to the clean air side of the filter.

RECIRCULATION. Heating costs can often be materially reduced by recirculating part of the warm air within the building during the winter months. The recirculated air should be returned through the filter, to temper the cold air and also to insure the removal of any dust or lint that it may contain. Following is the method of figuring fuel economy resulting from recirculation:

$$\frac{\text{cfm x 60 min. x (temp. diff.) x operating hrs.}}{\text{55 cu. ft. per btu. x net btu. per ton of coal}} \left.\right\} \text{equals tons of coal saved.}$$

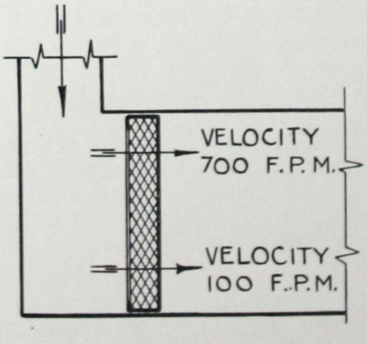
Example:—Indoor temperature assumed 70°.
Outdoor temperature (depending on locality) 36° F.
Temp. Diff. = Indoor temp.—aver. outdoor temp.
Operating hours, 1,400 per heating season.
Heating value per lb. of coal, after deducting for losses in boiler, etc., 7,000 btu.

$$\frac{1000 \text{ x } 60 \text{ x } 34 \text{ x } 1400}{55 \text{ x } 7000 \text{ x } 2000} = 3.7 \text{ tons per 1000 cfm.}$$

In some states recirculation is not permitted in certain types of buildings while in others as much as 75% to 80% recirculated air is allowed which makes it necessary to consult the local code in each case.

(B.) UNIFORM AIR FLOW

The customary air velocities in ducts are several times higher than those prevailing at the face of the air filter. The connections between the filter and the duct system or fan inlet should therefore be sloped as gradually as possible. Best results will be obtained if the incoming air enters the filter chamber perpendicular to the filter. While it is always desirable to use a filter of nearly equal height and width, it is particularly recommended when the filter is to be placed near the fan inlet With very tall and narrow or low and wide filters, some parts of the filtering surface may be so far from the fan inlet that the air flow is necessarily restricted, which produces an overload on the remaining area. Filters arranged diagonally, or parallel to the air flow, sometimes suffer for the same reasons.



Uneven air velocities resulting from the air entering or leaving at right angles to the filter, causes high operating resistance.

If a uniform air distribution cannot be obtained by ordinary means, provision should be made for baffles or vanes to direct the air flow in the desired way. Their position can be determined only approximately in advance and it is best to provide some adjustment for the baffles which may be made after the system is in operation.

(C.) ACCESSIBILITY

It is important to provide sufficient space in front of as well as behind the filter to make it accessible for inspection and service. A distance of 2 feet with viscous type filters and 3 feet with the Airmat may be regarded as the minimum. Access doors of convenient size should be placed in the sheet metal connections both in front of and behind the filter. Electric lights which can be switched on from the outside should be installed in order to make possible a more thorough inspection and easier servicing of the filter.

(D.) LOCATION OF INTAKE

In preparing the layout of a filter installation thought should be given to the location of the air intake. It should be placed as high above the ground line as possible and on the side of the building away from the prevailing winter winds if practical, to prevent any excessive or unnecessary dust load on the filter. The intake should be protected with weather louvres and covered with ½ in. mesh screen which should be removable for cleaning. If the filter must be placed close to the intake, the opening should be directly in front of and as nearly the same size as the filter area to assure uniform air distribution.

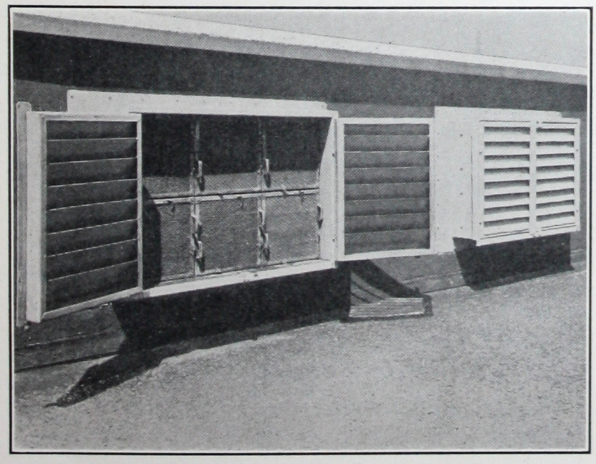
When the filter must of necessity be located so the air turns at a sharp angle upon entering or leaving the filter, it is desirable to place the filter as far from the point where the air turns as possible to secure uniform air velocities over the entire filter area.

Proper air distribution, because of its effect upon the ultimate performance, is one of the most important factors to be considered in designing an air filter installation.

3. INSTALLATION OF AIR FILTER

PROPER DUCT DESIGN. The ducts required for housing the filter and connecting with air supply system, should be well constructed of sufficient heavy sheet metal and properly braced if of large size. Taper connections to filters should be as gradual as possible, but the angle should never be less than 45°—preferably 60°. The location of access doors and inspection lights is explained under **Accessibility.**

AIRTIGHT DUCT CONNECTIONS. Since air filters are as a rule installed on the suction side of the fan, any leaks in the sheet metal housing will admit considerable amounts of uncleaned air into the clean air ducts. This point deserves a great deal of attention. Considering that it is just as important and much more difficult for the filter to extract the last few percent of dust from the air as to eliminate the great bulk of the impurities, it would be poor policy to let even small amounts of outside air mix with the clean air and reduce the efficiency of the filter, even to the point of destroying its effectiveness.



Filters installed in a monitor and serviced from roof. Note well designed weather louvres hinged for access.

For this reason the access door on the clean air side should be tight fitting and the edges lined with felt. All bolted or riveted connections and seams, especially the joint between the housing and floor line should be as nearly air-tight as possible and should preferably be puttied.

LOCATION OF DRAFT GUAGES. With unit and Airmat filters it is particularly desirable to provide each installation with a draft gauge with which to establish the proper maintenance. By determining the allowable resistance at which the installation should operate the draft gauge will act as an indicator to show when maintenance is necessary. A draft gauge is not so necessary with an automatic filter since the air volume does not depend upon any definite maintenance routine.

Draft gauges should be installed on the outside of the duct with static tubes passing through the sheet metal and projecting well in front of and behind the exposed filter surface. Several standard designs are available and can be purchased at reasonable prices.

WEATHER PROTECTION. Filters for ventilating installations are not usually located outdoors without the protection of pent houses. In many industrial applications and in practically all installations for compressor and Diesel engine service, filters are placed wherever space is available, often outdoors. Such filters should be protected from the weather by small housings which are frequently built integral with the filter structure itself, and provided with louvred inlet to prevent rain or snow from blowing in on the filter surface.

AMERICAN AIR FILTER LITERATURE

BULLETINS

No. 117 *American Filters for Warm Air Furnaces*
No. 120 *American Filters for Engines and Compressors*
No. 201 *American Unit Type Filters*
No. 230 *American Airmat Dry Type Filters*
No. 240 *American Multi-Panel Automatic Air Filters*
No. 250 *American Phoenix Constant-Effect Air Filters*
No. 260 *American Airmat Dust Arrester*

BOOKLETS

Filtered Air in Building Ventilation and Air Conditioning
American Air Filters in Industry
The Air You Breathe. (Airgard Electric Window Ventilator)
The Application of Air Filters to Kitchen Range Hoods
Gold Out of the Air. (Citing Actual Economies of Air Filters)
The Application of Air Filters to the Ventilation of Electrical Equipment

PERFORMANCE SURVEYS

Ventilation and Air Conditioning

Continental Illinois Trust Co. (Air Filters and Air Washers)
Union Trust Co. (Air Filters and Air Washers)
Duluth Public Schools (Airmat Filters)

Industrial Applications

A Large Radio Manufacturer (Finishing Room)
Youngstown Sheet & Tube Co. (Mill Motor Ventilation)
Big Four Railroad (Air Compressors)
Studebaker Corporation (Air Compressors)
Oklahoma Natural Gas Company (Gas Engines)

Airmat Dust Arresters

Bausch & Lomb Optical Co. (Gold Buffing)
Garlock Packing Co. (Asbestos Fibre)